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DATE: February 18, 2015
Report No: G13-211

PGAL, Inc.
3131 Briarpark, Suite 200
Houston, Texas 77042

Attention: Mr. Costas Georghiou, P. E.

Reference: Trench Safety Report
Garden Oaks and Shepherd Park (Central)
Drainage and Paving
WBS No. M-000285-0001-4
Houston, Texas

Dear Mr. Georghiou:

Submitted herein are our recommendations for the trench safety for the open cut excavation/trenching/shoring involve in the proposed drainage and paving improvements. The project entails improvement of approximately 16,000 linear feet of storm sewers, sanitary sewers and pavements, and approximately 1,700 linear feet of ditch improvements as part of the Phase I work in the Garden Oaks and Shepherd Park (Central) Area in Houston, Texas.

The approximate flow line depth of the proposed storm sewers is about 20 feet near Judiway St., and about 17 feet at the Alba Road/Chamboard Lane intersection, and approximately 10 feet near Lehman St., and at about 8 feet near the Brinkman Street/Pinemont Street intersection. The existing open ditch is approximately 6 feet deep. The improved ditch will have the same depth but the side slopes will be improved and protected by articulating concrete blocks (ACB). Both open cut/trenching and tunneling/trenchless installation techniques will be employed.

OSHA Classification

Maintaining stability of sidewalls and base of a trench is necessary for the safety of the construction crew working in or near it and for mitigating risks of damages to adjacent structures/facilities due to lateral or vertical movements. At the federal level, Occupational Safety and Health Act (OSHA) requires protective systems for all trenches exceeding 5 feet in depth. Protective systems may be required for trenches shallower than 5 feet in depth if there are indications of potential ground movements. OSHA has developed a soil classification system to be used as a guideline in determining sloping

and protective system requirements for trench excavations. This system has set forth a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing degree of stability. Based on the soil conditions from the borings and groundwater information from the borings and piezometers, ATL recommends classifying the top 10 feet of the onsite stiff to hard clay soils (CL/CH) as OSHA Soil Type “B” for the determination of allowable maximum slope or selection and design of the protective system. All onsite clay soils below a depth of 10 feet, and soft to firm clays, shall be classified as OSHA Soil Type “C”. Any soft/wet soils, sands (SP/SM/SC), silts (ML), silty clays (CL-ML), and any soils that are saturated or are subject to seepage pressure or vibrations shall be classified as OSHA Soil Type “C”. In mixed soils conditions, the most critical soil classification shall be used.

Excavations

The excavations can be made using open slopes, stepped back to stable slope, vertical cuts supported with shoring, sheet piles or other suitably designed retaining system. The excavation should be performed in accordance with the current OSHA 29 CFR Part 1926 of OSHA (Trench Safety System). For short-term exposure during construction, open slopes in OSHA Type “C” soils should not be steeper than 1(V): 1.5(H). For long-term exposure (greater than 72 hours) during construction, open slopes in OSHA Type “C” soils should not be steeper than 1(V): 2(H). For OSHA Type “B” soils, open slopes is no steeper than 1(V): 1(H) is recommended. We do not recommend using unsupported vertical cuts.

Earth Pressures

For the trench support system, the lateral pressures exerted by surrounding soils are presented in the attached Figures 1 through 3. Temporary earth retaining walls are sometimes designed assuming an equivalent fluid pressure, in such cases, a lateral earth pressure equivalent imposed by a 84 PCF and 102 PCF fluid is recommended for cohesive soils below and above the water table, respectively; in sandy soils, a lateral earth pressure equivalent imposed by a 48 PCF and 85 PCF fluid is recommended for soils below and above the water table, respectively. In general, a surcharge magnitude of q psf will result in lateral earth pressure of $0.5q$ in cohesive soils and $0.4q$ in sandy soils. Timber shoring as outlined in 29 CFR Part 1926 of OSHA recommendation may be used in the construction of trench supporting system.

Due to the presence of the roadway adjacent to the proposed construction excavation along the project alignments, the effects of vehicular traffic should be considered in the design of the trench support systems. We recommend that a H20 vehicle loading be considered adjacent to the pit for design purposes, surcharge loading due to construction machinery should be considered. Boussinesq’s equation should be used for computing both horizontal and vertical stresses imposed by a surface surcharge load. Stockpiling of excavated material may not be allowed near the excavation. Generally, a distance of one-half the excavation depth on both sides of the trench should be kept clear of any

excavated material. If this is not possible due to space limitations then the retaining system design should take into account the surcharge loads.

Bottom Stability

Where granular soils are encountered at trench bottom, dewatering should be performed to lower the groundwater to a depth of at least 3 feet below the excavation bottom. In cohesive soils, the trench bottom stability can be evaluated using the procedure outlined in Section 5.1.2 of ATL Report No. G13-211.

Groundwater Control

Free water was encountered during drilling operation in most borings except B-5 and B-9 at depths between 10 and 27 feet; free water was measured at depths ranging from 10 to 23 feet at completion of drilling. Borings B-1, B-11, B-19 and B-21 were converted into Piezometer PZ-1 through PZ-4 after completion of drilling and soil sampling. Water level in PZ-1 through PZ-4 was measured after 24-hour at a depth of about 17, 11, 11 and 13 feet, respectively. Water level in PZ-1 through PZ-4 was measured after 7 days at a depth of about 16, 11, 11.5 and 13 feet, respectively. Water level in PZ-1 through PZ-4 was measured after 30 days at a depth of about 15, 11, 11 and 12 feet, respectively.

Based on the proposed invert elevation and the groundwater information gathered during our field investigation, water line construction excavations approaching or exceeding about 10 feet in depth will likely encounter groundwater, especially when the excavations stay open for 24 hours or more. It should be noted that groundwater level will fluctuate with the amount of precipitation and the prevailing environmental conditions prior to and during construction.

The flow of groundwater may vary depending upon depth of construction and weather conditions. A conventional sump and pump arrangement may be used for the trench excavations in cohesive soils to a depth of 15 feet. Below this depth, multi-staged pumps or well points will be required. Where non-cohesive soils are encountered or if the inflow is fast, then dewatering using well points may be necessary. Groundwater control should be in general accordance with the City of Houston Standard Specifications, Section 01578. More detailed information regarding the soils and groundwater at individual locations can be obtained from our geotechnical report G14-211. We appreciate the opportunity to work with you on this project. Please call should you have any questions or need additional information.

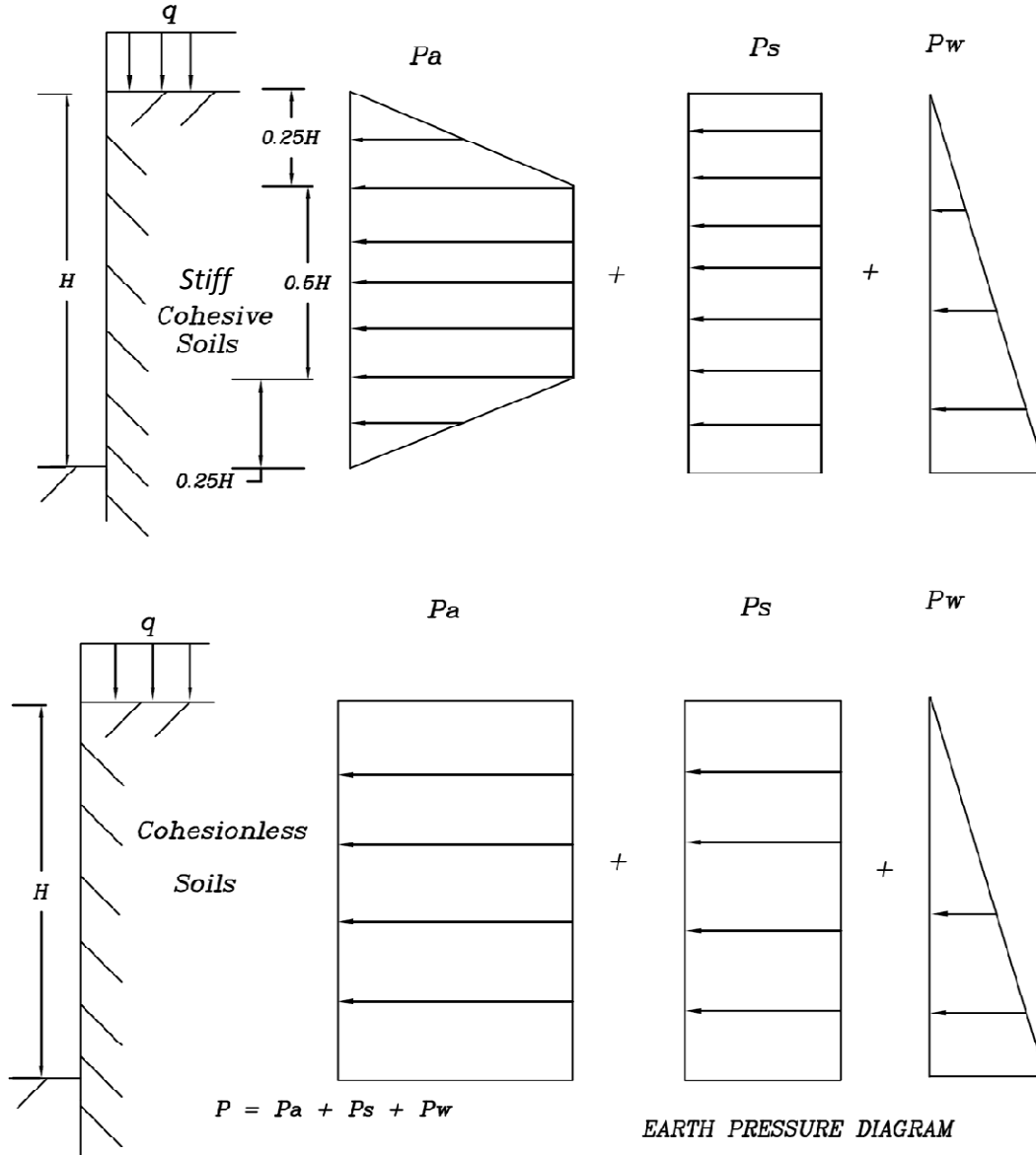
Sincerely,



Peng Sia Tang, P.E.
Manager, Geotechnical Services



Enclosures: Figures 1 through 3 – Earth Pressure Diagrams



Where P = Total lateral pressure (psf)

P_a = Active earth pressure (psf) = $K_A \gamma H = 0.4 \gamma H$ for Stiff Clays

= $0.65 K_A \gamma H = 0.25 \gamma H$ for cohesionless Sands ($0.33 \gamma H$ for loose sand)

P_s = Lateral pressure due to surcharge load (psf) = $0.5q$ for Clays

P_w = Hydrostatic pressure (psf) = $62.4 \times \text{water depth}$ = $0.4q$ for Sands
($0.5q$ for loose Sands)

H = Depth of braced excavation (ft)

q = Surcharge load (psf) usually taken as 500 psf

γ = Submerged density of soils (pcf) = use 60 pcf (use 50 pcf for loose Sands)

Source: Peck, R.B. 1969. "Deep Excavations and Tunneling in Soft Ground".

EARTH PRESSURE DIAGRAM

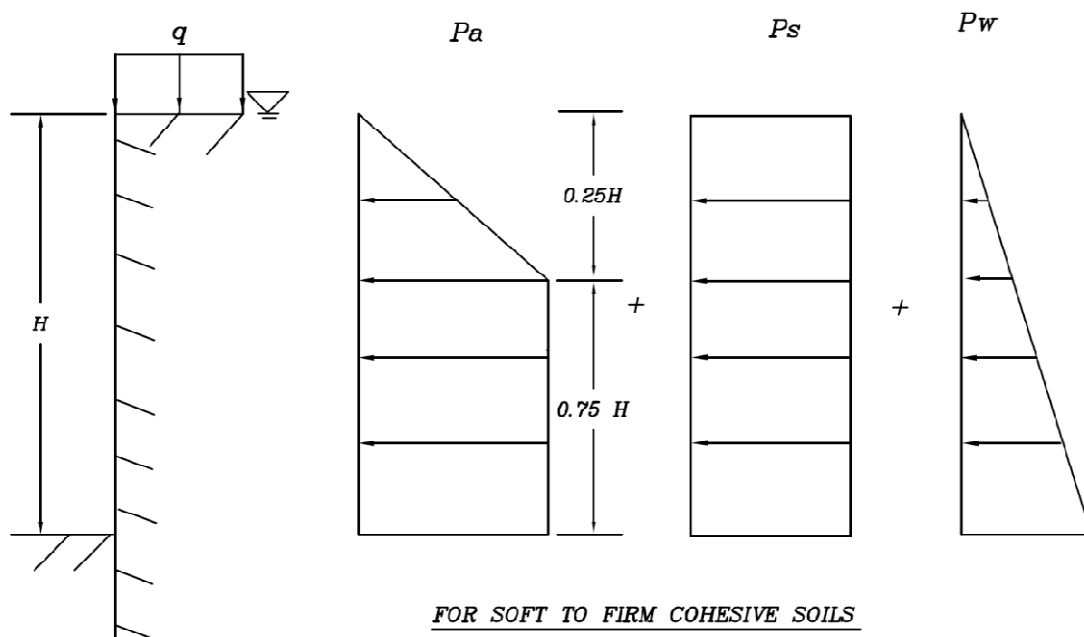
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GARDEN OAKS AND SHEPHERD PARK (CENTRAL)
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FIGURE 1



Where P = Total lateral pressure (psf)

P_a = Active earth pressure (psf) = $1.0K_a\gamma H$ for soft clays

K_a = Active Earth pressure coefficient

$$= 1 - m \frac{2q_u}{\gamma H} = 1 - m \frac{4C}{\gamma H} \text{ (taking } C = \frac{q_u}{2} \text{)}$$

Here $m=1$ for $N < 4$ and $m=0.4$ for $N > 5$

N = Stability number = $\gamma H / C$

P_s = Lateral pressure due to surcharge load (psf) = K_a for clays

P_w = Hydrostatic pressure (psf) = $62.4 \times \text{water depth}$

H = Depth of braced excavation (ft)

q = Surcharge load (psf) usually taken as 500 psf

γ = density of soils (pcf) = use 50 pcf below groundwater and 110 pcf above groundwater

q_u = Unconfined compressive strength, psf

C = Undrained shear strength, psf

Note: Neglect hydrostatic pressure above groundwater level

Source: Peck, R.B. 1969. "Deep Excavations and Tunneling in Soft Ground".

EARTH PRESSURE DIAGRAM

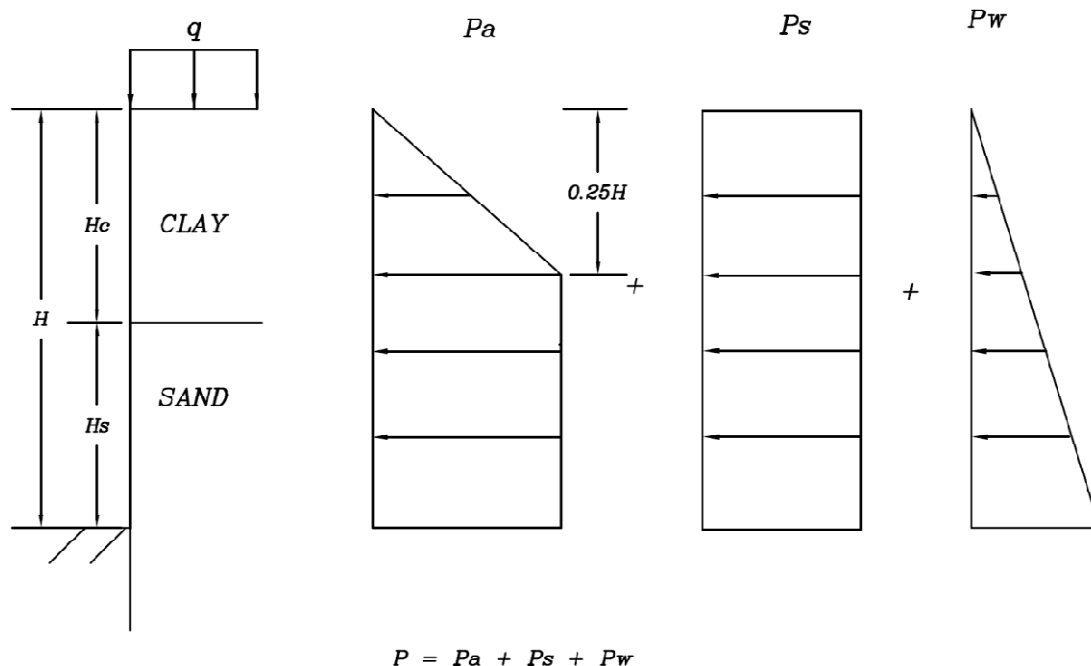
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FIGURE 2



Where P = Total lateral pressure (psf)

P_a = Active earth pressure (psf) = $K_A \gamma H = 0.4 \gamma H$

P_s = Lateral pressure due to surcharge load (psf) = $0.5q$

P_w = Hydrostatic pressure (psf) = $62.4 \times \text{water depth}$

H = Depth of braced excavation (ft)

q = Surcharge load (psf) usually taken as 500 psf

γ = Submerged density of soils (pcf) = use 60 pcf

Source: Peck, R.B. 1969. "Deep Excavations and Tunneling in Soft Ground".

EARTH PRESSURE DIAGRAM

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FIGURE 3